

# Quantum and Nonlinear Optical Imaging

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In this contribution, we review some recent research in the field of quantum and nonlinear optical imaging.

One of the earliest examples of the use of nonlinear optical techniques for image formation was that of infrared upconversion [1], a technique that can provide noise-free conversion of infrared radiation to the visible where it can be detected more efficiently. Some of this early work stressed the use of infrared upconversion for astronomy [2]. More recent work has looked into the possibility using quantum coherence to increase the efficiency of the upconversion process [3]. Nonlinear optical interactions involving photorefractive materials can also be used to increase the brightness of certain microscopic images [4].

There has also been great interest in the use of quantum states of light in the formation of images, as reviewed by Lugiato et al. [5]. One example is the possibility of performing lithography with a resolution better than that predicted by the standard Rayleigh criterion by making use of the properties of entangled photons [6]. Recent theoretical work [7] has shown that it is possible to maintain strong quantum correlations even in the intense output of a parametric amplifier; it is hoped that this procedure can allow the use of light beams sufficiently intense to efficiently excite two-photon absorption in lithographic plates. Another example of the use of quantum states of light is in process of coincidence imaging [8], also called “ghost” imaging because the photons that are used to record the image never pass through the object to be imaged. Recent work [9] has demonstrated that quantum states of light are not needed to perform coincidence imaging; classical correlations can be used to achieve much the same results.

The majority of the research performed to date on the generation of entangled photon pairs has made use of second-order nonlinear optical interactions. However, third-order interactions offer many benefits, including the fact that the entangled photons can be at approximately the same wavelength as the pump photons. We are interested in the study of third-order interactions in atomic vapors, in which case phase-matching considerations require the radiation to be emitted in the forms of rings [10] or more complicated patterns [11]. We have observed quantum features in some of these situations [12].

This work was supported by the US Army Research Office, the Office of Naval Research, DARPA, and the U.S. Department of Energy.

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